Name ____ Period _____

Lab Partners ____

Porosity and Drainage Rate of Soils

Introduction

Soils are composed of different physical combinations of mineral particles and organic matter in many different sizes. One of the most important physical properties of soil is known as soil texture. **Soil texture**, by definition, is the size of mineral particles in the soil. Mineral particle size is a major factor that influences both the amount of air in soil (**aeration**) and the capacity of soil to retain water (**water holding capacity**). The volume of air and water that soil can hold is known as the soil pore size or **porosity**. The larger the soil particles, the larger the soil pore size will be (see Figure 1). The reverse is also true—the smaller the soil particles size, the smaller the pore size (Figure 1).

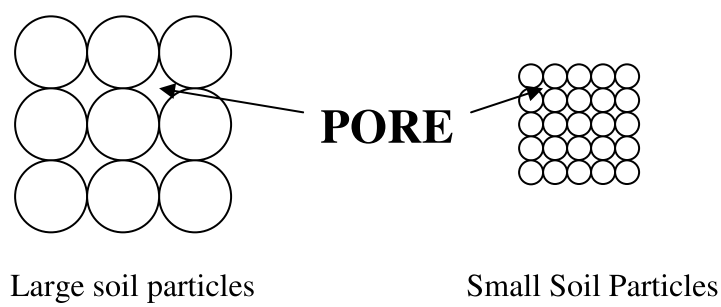

Figure 1. Pore size is directly proportional to particle size.

Water tends to drain more rapidly through larger soil pore size than small pores. As water runs through any type of soil, it pulls small amounts of air along with it. When water enters soil that has a small pore size, the air fills the pores or voids in the soil. As the small pore spaces are filled, the soil holds or retains a greater amount of water. This is why it is important to have a good mixture of different types of soil for plant growth. A combination of large and small pores provides both better aeration and water retention in soil.

Permeability is another key characteristic of soil. **Permeability** is the relative ease in which water and air can move through soil. Water flows through soils with high permeability very easily. Soils with low permeability allow much less water flow or drainage. Soils that have high permeability can be pictured as being loose and soils with low permeability can be thought of as being tight or compacted.

Compaction of soil also plays a major role in the amount of water that is drained through soil. **Compaction** occurs when pressure is applied to a soil surface. As soil becomes compacted, the pores in the soil become smaller. The number of large pores decreases, which, in turn, lowers the aeration level of soil. Compacted soil also leads to a decrease in permeability.

Permeability also decreases when soil becomes saturated with water. Saturation of soil and high levels of introduced water (rainfall for example) lead to runoff of water. **Runoff** is water that is not absorbed by the soil and flows to lower ground, eventually draining into streams, lakes, rivers, and other bodies of water. Excessive amounts of water runoff can cause severe flooding, which can lead to extensive property damage.

The composition and size of soil particles determine the type of soil. Soil type, in turn, determines the numbers and kinds of organisms that live in the soil. Thus, different kinds of plants and animals in an ecosystem are supported by different soil types. For example, desert plants survive best in fast-draining soil. Plants that require larger amounts of water survive best in soil that holds more water and drains more slowly.

Quick Review

Define the following words:

- Soil texture-
- Aeration-
- Water holding capacity-
- Porosity-
- Permeability-
- Compaction-
- Runoff-

Data

Table 1: Dry Soil Drainage

Soil	Time of Drainage (s)
Tube 1 Loose Soil	
Tube 2 Packed Soil	

Table 2: Wet Soil Drainage

Soil	Time of Drainage (s)
Tube 1 Loose Soil	
Tube 2 Packed Soil	

Table 3: Permeability and Porosity

	A	B	C	D	E
Soil Type	Initial Time (s)	Amount of Water Remaining in Graduated Cylinder (mL)	Pore Space Volume (mL) (100mL – Column B)	Water Drained From Tube (mL)	Water Retained (mL) (C – D)
Tube 1 Sand					
Tube 2 Fine Gravel					
Tube 3 Coarse Gravel					

Analysis

Day 1

1. Which drained faster, the dry loosely-packed soil or the dry tightly-packed soil?

2. Which drained faster, the wet loosely-packed soil or the wet tightly-packed soil?

3. Which drained faster, moist or dry soil?

4. During a rainstorm, what type of soil would drain the fastest and which would drain the slowest:

A. Loose soil at the beginning of the storm
B. Packed soil at the beginning of the storm
C. Loose soil at the end of the storm
D. Packed soil at the end of the storm

Fastest ________ Slowest _______

5. As compaction increases, permeability _____________. As saturation increases, permeability _______________.

Day 2

6. Which type of soil (sand, fine gravel, or coarse gravel) has the biggest particle size?

7. Which type of soil (sand, fine gravel, or coarse gravel) has the highest porosity, or largest spaces between its particles (see Pore Space Volume in Column C in your table)?

8. Which type of soil (sand, fine gravel, or coarse gravel) retained the most water (see Column E in your table)?

9. Calculate the permeability of each soil type using the following equation:

Permeability = 1 / Initial Time for water to reach bottom of tube

Sand _________ Fine Gravel _______ Coarse Gravel _______

10. Which type of soil (sand, fine gravel, or coarse gravel) has the highest permeability?

11. As particle size increases, porosity _____________ . As particle size increases, water retention ______________.

12. As particle size increases, permeability ____________. As porosity increases, permeability ______________.

Porosity and Drainage Rate of Soils: Procedures

Activity One: Drainage Rate of Dry Soil

1. Obtain 2 clear tubes with open ends.
2. Rubber-band 2 pieces of cheesecloth to one end of each tube.
3. Place each tube upright, with cheesecloth end down, in a plastic cup.
4. Measure 40 mL of soil using the appropriately labeled cup.
5. Place the 40 mL of loosely packed soil in tube #1.
6. Place the same amount of soil (40 mL) in tube #2. Tightly pack the soil down, using a wooden dowel.
7. Hold tube #1 above the plastic cup and pour 20mL of water into the tube. Use a stopwatch or a watch with a second hand to time the drainage of the water. Start timing as soon as all of the water has been poured into the tube.
8. Stop timing when the water stops dripping from the bottom of tube #1. Record time under "Time of Drainage" for "Loose Soil" in Data Table 1.
9. Repeat Steps 7 and 8 for tube #2. Record the time for drainage of the water in tube #2 in seconds under "Time of Drainage" for "Packed Soil" in Data Table 1.
10. Pour the water from each cup into the appropriate bucket. Save the tubes with the soil and the cups for Activity 2.

Activity Two: Drainage Rate of Wet Soil

11. Place each of the tubes with the wet soil in the cups once again.
12. Hold tube #1 above the cup and once again fill the tube with 20 mL of water. Start timing as soon as all of the water has been poured into the tube.
13. Stop timing when the water stops dripping from the tube. Record drainage time for the first tube in seconds under "Time of Drainage" for "Loose Soil" in Data Table 2.
14. Repeat steps 12 and 13 for tube #2. Record the time for the second tube under "Time of Drainage" for "Packed Soil" in Data Table 2.
15. Dispose of the soil in the garbage can and clean the tubes using the appropriate buckets.

Activity Three: Permeability and Porosity of Varied Soil Types

16. Obtain a tube with one end closed.
17. Using the appropriately labeled cup, measure out 100 mL of sand in the tube.
18. Measure 100.0 mL of water into a graduated cylinder. This will be the initial amount of water.
19. Start a timer and slowly pour water from the graduated cylinder into the tube until the sand is saturated (water reaches the top of the soil). Record the amount of time it takes the water to reach the bottom of the tube in Data Table 3 under "Initial Time."
20. Set the graduated cylinder containing the remaining water aside for now.
21. Record the "Amount of Water Remaining in the Graduated Cylinder" in Data Table 3.
22. Subtract the amount of water remaining in the graduated cylinder from the initial volume of water, 100 mL. This will give the volume of the pore spaces in the sand. Record this value in Data Table 3 as "Pore Space Volume."
    - 100 mL – (Column B)
23. Empty the graduated cylinder in the sink.
24. Pinch the tube and pour the water retained in the sand from the tube into the empty graduated cylinder. Be sure not to pour any of the sand into the graduated cylinder. Record this amount of water as "Water Drained from Tube" in Data Table 3.
25. Subtract the "Water Drained from Tube" from the "Pore Space Volume" of the sand. This value will be the volume of water retained. Record this value in Data Table 3 as "Water Retained."
    - Column C – Column D
26. Dispose of the sand sample in the appropriate bucket and repeat steps 17-25 for the fine and coarse gravel samples.